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Assessing the Effectiveness of Landscape Fuel Treatments on Fire Growth and Behavior

Background

Recent research suggests that landscape-scale fuel modifications, such as prescribed fire, are the most effective way to modify the behavior and growth of large fires (Finney 2001). However, the effectiveness of fuel treatments remain a subject of debate due in part to the weather conditions they will or will not perform under, treatment method, completeness of the application, treatment design (i.e., placement, pattern, size), and the difficulty in evaluating the effectiveness of the proposed treatment. Simulation modeling allows the user to partially address these issues under various weather and fuel scenarios and provides a "tested" outcome for field application. This study presents a methodology for assessing the effectiveness of landscape fuel treatments on fire growth and behavior by utilizing previous fire locations, historical weather, and fire growth and behavior models.

Analysis Area

The treatment area is located approximately 20 miles south of Cedar City, Utah and is adjacent to the communities of New Harmony and Harmony Heights. The project area (approx. 2,000 acres; 5,300 ft) is on Bureau of Land Management (BLM) administered land and bounded tightly by private ownership to the north, Interstate 15 (I-15) to the east, the Dixie National Forest and Pine Valley Mountain Wilderness Area to the west, and BLM, State, and private inholdings to the south.

Located on a relatively flat, east, southeast bench, understory vegetation is primarily grass, sage brush, serviceberry, and oak, with juniper and pine dominating the overstory. Summer cold fronts contribute to strong winds that are channeled through the I-15-Black Ridge corridor and into the project area.

Objectives

The objectives of the project were to reduce fire intensity, occurrence of crown fire, and mid-/long-range spotting and to increase native plant diversity and enhance wildlife forage. This was accomplished through herbicide application and fuel reduction. Treatment boundaries were delineated by ownership, previously chained areas (1960s), and wildlife needs and is reflected in an asymmetrical, amoeboid design. Sage-dominated areas were applied with several applications of an herbicide (Tebuthiuron or "Spike"). Encroaching juniper was manually cut (lop-and-scatter) and is being followed up with pile and broadcast burning.

Methods

Specific information about the project area, such as objectives of the proposed treatment, type of treatment (e.g., prescribed fire, manual thinning), pre- and post treatment condition of the entire fuel complex, and supporting geographic information system (GIS) data were obtained from the BLM. A 32-year fire occurrence layer for the BLM and USDA Forest Service was used to derive a fire density grid using Arc View/Spatial Analyst. Historical weather information was imported into FireFamily Plus and fuel moistures (i.e., 1-, 10-, 100- hour, live herbaceous, live woody) were obtained using the Percentile Weather Report and compared with local field sampling to validate and adjust the values. Windspeed, wind direction, temperature, and relative humidity were obtained from FireFamily Plus. Windspeeds were then modified to account for probable maximum 1- minute gusts and directions were developed based on actual hourly RAWS data that adequately represented the appropriate percentile weather. All weather and fuel moisture parameters were classified into 75th (moderate), 85th (high), and 95th (very high) percentiles (see Table 1).

Spatial vegetation data for the project area was extracted from a larger 15 million acre study area to assign polygons to one of 65 final vegetation classes. These vegetation classes were cross walked to 44 fuel models. Canopy cover, stand height, crown-base height, and crown bulk density were developed based on field data, anecdotal observations, and published work. Moderate and severe custom fuel files (*.FMD) were built in FARSITE to reflect

The JFSP, a partnership of six federal wildland fire and research organizations, provides scientific information and support for fuel and fire management programs.

JFSP Contacts

Erik Berg
Program Manager
208-387-5349

Becky Jenison
Program Assistant
208-387-5958

Tom Wordell
Fire Technology Transfer Specialist
208-387-5865

jfsp.nifc.gov

the differences in fire behavior between moderate and high/severe conditions.

Terrain, fuel model, and canopy information was used to construct two modeling landscapes: pretreatment and post treatment. FARSITE (Finney 1998) was used to model fire growth and spotting potential. To produce fire growth and behavior output consistent with observations, model checking, modifications, and comparisons were done using known fire perimeters and weather (Finney 2000). FlamMap (Finney, in preparation) was used to calculate fireline intensity, surface flame length, and crown fire activity.

Table 1. Weather and fuel moisture information for the 75th, 85th, and 95th percentile as reported by FireFamily Plus and modified as noted.

	75th	85th	95th
1-hour (%)	4	4	3
10-hour (%)	6	5	5
100-hour (%)	9	7	6
Live herbacious (%)[a]	90	80	60
Live woody (%)[a]	110	100	90
Temp. min. (°F)	56	59	64
Temp. max. (°F)	87	89	92
RH min. (°F)	16	14	10
RH max. (°F)	47	40	28
20-ft Windspeed (mph)[b]	17	19	23
Wind direction (°)[c]	190–235	190–235	190–235

[a] *Adjusted from the Seasonal Severity Summary based on local field sampling.*
[b] *Adjusted from the Seasonal Severity Summary to account for wind gusts (Crosby and Chandler 1966).*
[c] *During the burn period (1100–1900 hours).*

Results

A modest reduction in fire size is apparent for each percentile weather and fuel condition. The 85th percentile showed the greatest percent change from the untreated condition (~18%), which is likely due to the removal of most of the pinyon-juniper, thus reducing the rate-of-spread, spotting distance, and the number of embers lofted. The 75th percentile simulation shows little change due to similarities between surface spread rates in sparse pinyon-juniper stands and recently burned/residual slash areas. As the weather conditions grew more severe (95th percentile) and the fire size increased, the effectiveness of the treatments on fire growth diminished (see figure below).

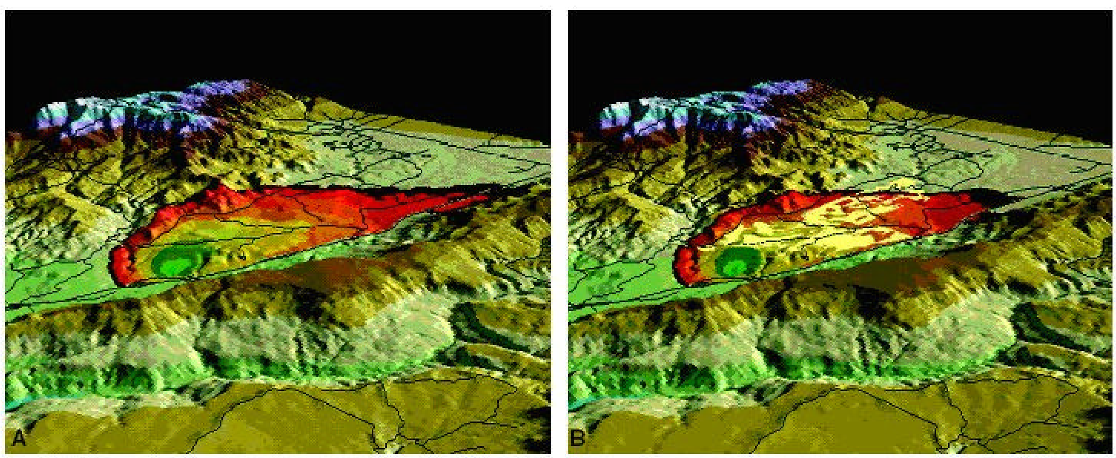

Figure 1. Eight-hour FARSITE simulation for the 85th percentile weather and fuel condition, pretreatment (left panel) and post treatment (right panel). Each color represents a 1-hour progression of the fire overlaid with roads (black) and the treated landscape (light yellow – right panel only). Black Ridge is in the foreground and the Pine Valley Mountains in the background (NW). Fuel modifications reduced the size of the fire by approximately 1,500 ac (18%).

A reduction in new ignitions ahead of the main fire front is evident under all three weather conditions. This is largely due to the removal of the pinyon-juniper. Changes in both intensity and flame length for all three percentile classes were realized in the project area and are recorded below. Although FlamMap differentiates between passive and active crown fire, Table 2 below summarizes both types of crown fire as one.

Discussion

A great deal of information can be obtained by modeling the effect of fuel treatments on fire growth and behavior and analyzing model outputs. Ideally, modeling will be done before the actual treatment is implemented so model findings can be incorporated to modify the treatment pattern, size, methods, etc. However, post analysis of fuel treatments, as in this case, can substantiate management decisions, yield useful findings for future projects, and identify weaknesses in treatment design and application. Theoretical modeling indicates the most effective treatment design tends to be those that have fuel modifications in succession and are distributed strategically across the landscape (Finney 2001). Moreover, the sooner a fire encounters a fragmented fuel complex the greater will be the effectiveness of that treatment on disrupting or locally blocking fire growth.

Table 2. FARSITE and FlamMap fire growth and behavior output for 75th, 85th, and 95th percentile weather and fuel moisture conditions.

	Pre	Post	Change from pre (%)
75th percentile			
Size (ac)	5,880	5,297	−9.91
Perimeter (mi)	18	18	0.00
Spot fires[a]	326	228	−30.06
Surface flame length (ft)[b]	2.97	2.53	−14.81
Fireline intensity (BTU/(ft-s))[b]	84	73	−13.10
Crown fire (ac)[c]	5,756	2,311	−59.85
85th percentile			
Size (ac)	8,588	7,056	−17.84
Perimeter (mi)	28	22	−21.43
Spot fires[a]	434	301	−30.65
Surface flame length (ft)[b]	14.93	8.41	−43.67
Fireline intensity (BTU/(ft-s))[b]	2,064	851	−58.77
Crown fire (ac)[c]	10,924	5,761	−47.26
95th percentile			
Size (ac)	24,881	23,202	−6.75
Perimeter (mi)	59	60	1.32
Spot fires[a]	1,139	1,054	−7.46
Surface flame length (ft)[b]	17.27	10.44	−39.55
Fireline intensity (BTU/(ft-s))[b]	2,843	1,343	−52.76
Crown fire (ac)[c]	10,924	5,761	−47.26

[a] *Number of spot fires initiated in the treatment area during a 6-hour period.*
[b] *Mean flame length and intensity.*
[c] *Passive and active crown fire.*

Conclusion

Managers have a growing need to assess the effectiveness of landscape fuel treatments; however, this need has outpaced the development of spatial models to accomplish the task. FARSITE, although not originally intended to do so, has been used to assess treatment effectiveness on fire growth and behavior. The methodology presented in this study uses FARSITE, but also incorporates FlamMap, FireFamily Plus, and previous ignition history to assess fuel treatment effectiveness. Although the approach has limitations, model outputs yield useful information for planning, assessing, and prioritizing fuel treatments. In the future, enhancements to FlamMap will enable users to evaluate landscape alterations on fire spread utilizing minimum travel time methods (Finney 2002) and aid in optimizing treatment design to mitigate fire behavior and spread.

Principal Investigator, Southern Utah Fuels Management Demonstration Project: Kevin C. Ryan, PhD; Acting Program Manager – LANDFIRE
Paper and Analysis by: Richard D. Stratton, Fire Modeling Analyst, Systems for Environmental Management

The full publication is available at: http://jfsp.nifc.gov/documents/jofaritcle_99-1-3-29.pdf

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